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**Biology Standard
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The Isolation of Species

California Education and the Environment Initiative

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California Natural Resources Agency
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California State Board of Education
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California Integrated Waste Management Board

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Contents

Lesson 1 Geographic Isolation

<i>California Connections: The Channel Islands– The Galápagos of California</i>	2
---	---

Lesson 2 Mechanisms of Isolation

None required for this lesson.

Lesson 3 The Influence of Human Activities on Animal Species' Population Structure

Tiger Species Information	6
---------------------------------	---

Lesson 4 Effects of Introduced Species

Changes in Populations	7
Consequences of Introductions	9

Lesson 5 Island Species' Vulnerability

None required for this lesson.

Assessments

Island Case Study—Alternative Unit Assessment Master	10
--	----

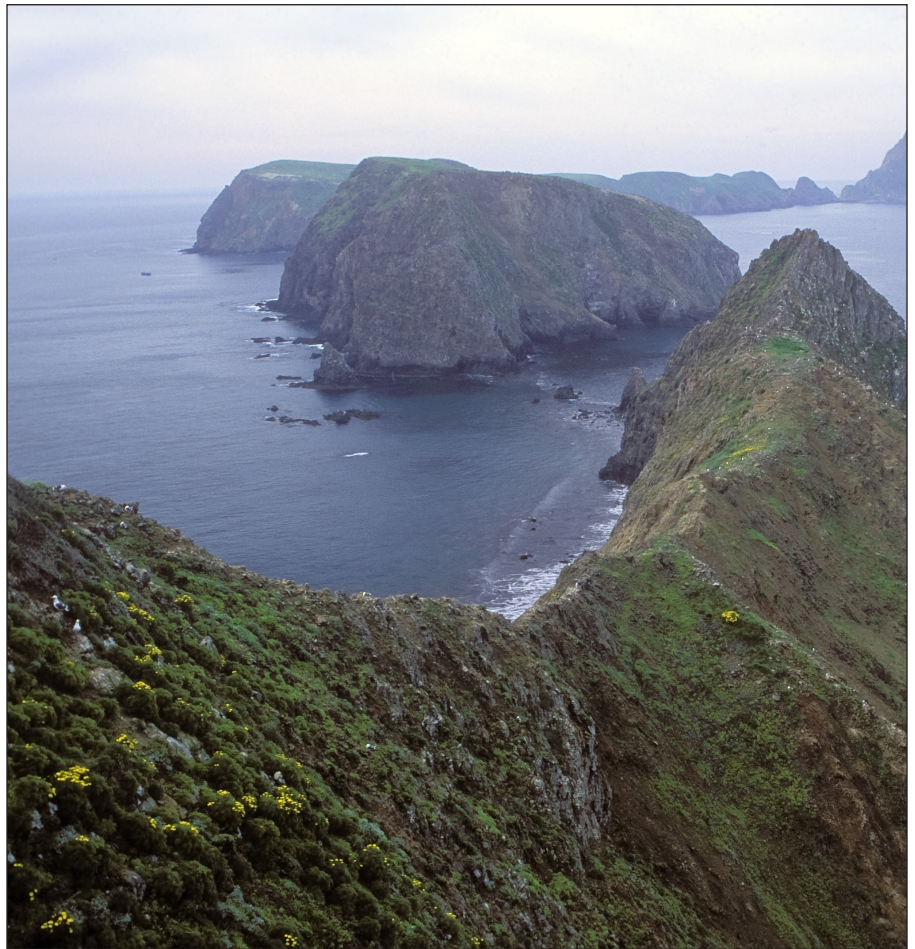
The Channel Islands— The Galápagos of California

You do not have to travel to the Southern Hemisphere to see islands with unique plants and animals. With a short boat ride, you can leave the developed coastline of Southern California and visit the untamed coasts of the Channel Islands. This chain of islands lies within 60 miles of mainland California. It extends from Point Conception at the western end of the Santa Barbara Channel to the U.S.–Mexico border.



Endemic Species

The Channel Islands of Southern California are often compared to the Galápagos Islands of South America. The eight islands harbor over 100 endemic species—species that live nowhere else. The island night lizard, for example, is found only on Santa Barbara, San Clemente, and San Nicolas islands. Santa Cruz Island is home to the island scrub-jay, a species that is larger and brighter than the mainland western scrub-jay. The island deer mouse and island fox are also endemic to the Channel Islands. The island deer mouse is the only native mammal found on all eight islands, each with a different subspecies. The island fox has diverged into separate



California Channel Islands

subspecies on the six islands where it lives. The islands support many endemic plants, including island ironwoods and island oaks, giant buckwheat, and varieties of manzanita, milk-vetch, bedstraw, lotus, and phacelia. Because these plants and animals are endemic to these islands, they are parts of one of Earth's most endangered ecosystems.

Allopatric Speciation

Unique organisms like these develop through allopatric speciation, a type of divergent evolution. This process occurs when one population of species is split into two populations that then become isolated from each other for a long time. The formation of new species takes place when the two populations are exposed to different environmental conditions and selection pressures. Since these populations are isolated from one another they no longer interbreed. As a result, over a long period of time, natural selection can result in changes to the genetic makeup of each population—the selected traits will not be shared between populations. As the isolation continues, each population will evolve its own set of traits that are different from the traits in the other population. After a long



Island deer mouse

time, even if the two populations come into contact with each other, they will no longer be able to successfully reproduce and produce fertile offspring. As such, they will have become separate species.

The fox populations of the northern Channel Islands provide a clear example of allopatric speciation. The four northern islands—San Miguel, Santa Rosa, Santa Cruz, and Anacapa—were connected during the Pleistocene Ice Age, approximately 18,000 years ago—when sea levels were significantly lower. When joined together, these four islands formed one large island known now as Santarosae. This island was home to the endemic island fox, a species that had evolved from the mainland gray fox. When sea levels rose, only the

higher elevations of Santarosae remained above water, dividing the large island into four separate islands. This event isolated the fox populations of the “new” islands.

There are differences among the four islands, and each population adapted to its island's environmental conditions. After a long period of separation, the populations each developed unique traits. For example, each island's fox species has a different number of tail vertebrae. There is other evidence of divergence in the island fox populations. Eventually, these isolated island fox subspecies could evolve into separate species.

In general, islands farther from the nearest mainland area have more endemic species—this is true for many

island chains around the world, including the Galápagos. This pattern is visible in the Channel Islands. The southern Channel Islands—Santa Catalina, Santa Barbara, San Nicolas, and San Clemente—were never connected to one another and are generally farther away from the mainland than the northern islands. The northern islands have up to 13 endemic plant species that live on just one island. The more isolated southern islands have as many as 30 endemic plant species that live only on a single island.

Isolation and evolution have caused dramatic differences between similar species living on mainland California and the Channel Islands. Some island species are larger than their mainland relatives. Such “gigantism” is seen in island scrub-jays, island deer mice, and giant buckwheat. In yet other species, evolution has led to “dwarfism,” where, over time, island organisms have evolved to smaller sizes than their mainland relatives. This is apparent in the island fox, which is the size of a housecat,

66% of the size (weight) of the mainland gray fox.

One striking example of evolutionary dwarfism is the Channel Island’s pygmy mammoth. Data show that when mammoths first colonized Santarosae by swimming six miles to the island during the last ice age, they were the same size as mainland mammoths—14 feet tall and weighing about 22,000 pounds. Within 20,000 years, a new species, the pygmy mammoth, had evolved on the islands, standing only 5 to 6 feet tall and weighing 2,000 pounds.

Scientists think that increased competition, brought about by living in the “close quarters” of the islands, caused this dwarfism. As sea levels rose, less food was available. Since smaller animals need less food to survive and there were no large predators on the islands, being large was not a benefit to these animals. Over many generations, through natural selection this species became smaller—more conducive to the island environment. (Both the Channel Island’s pygmy mammoth and its mainland relatives are now extinct.)

The traits that make island species successful in an island environment can also



Channel Island scrub-jay

make them vulnerable to extinction. Because their gene pool is small, island species do not have much resilience if environmental changes occur. If a disaster occurs—such as the introduction of a disease—a species can go extinct in a short time span. This almost happened to island foxes living on Santa Catalina Island. When canine distemper virus was introduced to the population by a racoon, 90% of the fox’s population died out within a year.

Introduced Species

The introduction of nonnative species can also affect the survival of endemic populations on islands. One-fourth of all plant species on the islands today are “introduced” species. Many of these newly introduced species outcompete native plants for space and water. Native plants are no match for the herbivores, such as goats, rabbits, deer, and pigs, that were introduced to the islands. Many of the islands’ animal species evolved without any major predators. If a predator is introduced to the island, native species may not have the behavioral traits that would help them survive. Feral cats and black rats eat seabird and songbird eggs and chicks. Likewise, introduced species may

damage the habitat. Introduced wild pigs have destroyed large quantities of native vegetation, causing erosion.

Richness of the Channel Islands

All organisms are the result of millions of years of mutation, random chance, and natural selection. Once a species is gone, it is gone forever. The

Channel Islands are among the world’s most precious resources. They provide essential breeding grounds for over 90% of the seabirds in Southern California. They also offer sanctuary for a rich diversity of marine life. Many threatened and endangered species exist in the Channel Islands and their surrounding waters. These islands are “living laboratories” of evolution.



Feral pig

Tiger Species Information

Lesson 3



Species Information

- Eight documented subspecies of tiger existed historically.
- As of 2007, only six subspecies remain, and all are listed as endangered.
- Length: average 3 meters.
- Weight: 300 kilograms.
- Lifespan: 15 years in the wild.
- Reproduction: gestation of 16 weeks, three to four cubs in a litter.

Habitat

- Dense vegetation found in forested areas and a regular water source.
- Currently, they occupy only 7% of their historical range.

Status

- Endangered status is the result of many types of human activities, including hunting for trophies, use of their body parts for medicinal purposes, deforestation of habitat, and loss of food sources.
- Expanding human populations in the region have altered land use practices, increasing habitat loss:
 - Forested regions have been converted to agricultural uses.
 - Commercially valuable tropical woods have been heavily harvested.
 - Expansion of urban areas, including new roads and industrial expansion, has fragmented forest habitats.
 - Hydroelectric dams have altered water sources, decreasing suitable habitat.

Changes in Populations

Lesson 4 | page 1 of 2

Group	Increases in Population Numbers	Decreases in Population Numbers
General Animals (applies to all animal groups)	Protected areas Breeding programs Habitat regeneration Protection status	Disease Pollution Decrease in food resources Over-exploitation (hunting/fishing) Increase in predators Loss of suitable habitat
Mammals	Protected areas Breeding programs Habitat regeneration Protection status	Same as “General Animals” plus: Disruption of migratory routes Illegal wildlife trafficking
Birds	Protected areas Breeding programs Habitat regeneration Protection status	Same as “General Animals” plus: Loss of nesting sites is part of loss of suitable habitat Predation of eggs and nestlings Collection for pet trade
Amphibians	Same as “General Animals” plus: Pollution regulation (very sensitive to pollution due to strong association with water)	Same as “General Animals” plus: Collection for pet trade
Reptiles	Protected areas Breeding programs Habitat regeneration Protection status	Same as “General Animals” plus: Loss of nesting sites Predation of eggs and nestlings Collection for pet trade

Changes in Populations

Lesson 4 | page 2 of 2

Group	Increases in Population Numbers	Decreases in Population Numbers
Fish	Same as “General Animals” plus: Protected status mainly applies to sharks	Same as “General Animals” plus: Loss of spawning sites Habitat degradation due to algal overgrowth Predation of eggs and larvae Collection for pet trade
Plants	Irrigation Pesticides Restoration Erosion prevention	Diversion of water sources Increased grazing Overgrowth by other plants Loss of habitat Competition for sunlight, water, or nutrients with other plants

Blackberry

The blackberry is at the top of the list for introduced plants that threaten native plant species in the Galápagos Islands. This species often overgrows native species and outcompetes them for space, light, and water. Its seeds are easily dispersed by birds that consume their fruit, allowing the plants to colonize vast areas rapidly. Blackberries also form thick, thorny hedges that cannot be crossed by some animals.

Feral Goats

Goats are strong grazers, so they compete with native species, especially in isolated parts of the Galápagos Islands where vegetation is sparse. They have completely altered natural habitats, changing forested areas into grasslands. The removal of vegetation has increased erosion, further altering the landscape. Additionally, giant tortoises cannot survive where the goats have removed the vegetation because the tortoises no longer have food or shade critical to their survival in the intense equatorial Sun.

Black Rats

Black rats are a known stowaway on ships since humans began exploring the world. They have been introduced to over 80% of the world's islands. Their introduction is estimated to be responsible for 40–60% of all bird and reptile extinctions in the world. Because the main part of their diet is eggs, black rats can dramatically affect populations of ground-nesting birds. They also eat vegetation, resulting in reduced populations of native plant species. In addition, black rats carry many diseases that can ravage native animal populations. They affect native species by competing with them for similar food resources and preying on them directly.

Red Fire Ants

Red fire ants are one of the most aggressive species that has been introduced into the Galápagos Archipelago. They are believed to have caused a decrease in reptile populations by eating tortoise hatchlings and attacking the eyes of the adult tortoises. They have also caused a reduction of scorpions, spiders, and native ant species. They were probably transported between islands on plants and in soil and on floating vegetation and debris. These ants are very territorial, especially around their nests. As part of their defense, they will attack and sting organisms as large as a juvenile deer. Red fire ants have also reduced populations of native insects that protect plants from insects that eat them. In addition, fire ants consume large amounts of vegetation.

Island Case Study

Located more than a thousand miles from the nearest continent, the Hawaiian Islands comprise one of the most isolated island chains in the world. They are considered a biodiversity “hotspot,” a biogeographic region with a significant reservoir of biodiversity that is threatened with destruction. Of the 20,000 native species identified on the islands, more than half are endemic, yet the islands have only two endemic mammals: the Hawaiian hoary bat and Hawaiian monk seal. There are no endemic snakes, but there are over 60 endemic bird species.

Recent impacts to the islands’ habitats have led to an extinction of 8% of the native species, and the listing of 29% of native species as either endangered or threatened. The use of land for plantations of sugarcane, pineapple, and coffee has fragmented, altered, or destroyed native habitat. Further, human activity on the islands has resulted in the introduction of nonnative species that prey on native wildlife. In addition, the human population has increased exponentially on the islands, with a 16% increase over the 10 years between 1990 and 2000. The swelling population has resulted in the development of housing tracts, resorts, and condominiums in many of the islands’ coastal areas.



Hawaiian nene

The Hawaiian nene, or nene, (pronounced “naynay”) is one of the most threatened endemic birds on the islands. Genetic studies indicate that it is a close relative of the Canada goose. It is estimated that in the late 1700s, the population was around 25,000. By 1952 only 30 geese remained alive. Captive breeding programs have allowed the population to

recover to 800—all bred from those remaining 30 individuals. Nene are found in scattered pockets on the islands of Maui, Kaua’i, the Big Island, and in the Honolulu zoo.

Nene are ground-nesting birds that prefer to nest in the lowlands in low vegetation. However, they can also be found at higher altitudes on the sparsely vegetated slopes of Hawaii’s

Island Case Study



Hawaiian Islands

volcanos. They have a long nesting season, and goslings take three months to fledge (be able to fly). The nene's ancestors had few natural predators when they



Feral pig

arrived on the Hawaiian Islands. As a result, the nene lost some of its ancestors' adaptations for avoiding predators.

In 1833, the mongoose was introduced to the islands in hopes of combating rats in sugarcane fields. The quickly-reproducing mongoose ate many rats but not enough to justify importing them. Because the mongoose is diurnal (hunts during the day) and rats are nocturnal (active at night), the mongoose ate other things, such as small mammals, insects, birds' eggs and juveniles. Feral pigs have a much longer history on the islands, dating back 1,600 years. They were brought

to the islands by sailors as a food resource in case sailors became stranded. Pigs travel in packs. Their feeding and wallowing behaviors destroy vegetation and disrupt nesting. Feral pigs are also known to feed on eggs of ground-nesting birds, like nenes.

Other factors also have affected the nene. Though now illegal, hunting and egg collecting once reduced the nene population. In certain areas, collisions with vehicles are a major source of fatalities. Habitat loss and scarcity of native food plants continue to threaten the nene throughout Hawaii.



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